

TRIFOLIUM STOLONIFERUM (FABACEAE) IN OHIO: HISTORY, HABITATS, DECLINE AND REDISCOVERY

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ABSTRACT

Trifolium stoloniferum Muhl. ex A. Eaton (Fabaceae) (running buffalo clover) is Federally listed as an Endangered species by the U.S. Fish and Wildlife Service. This species formerly grew in eight states from West Virginia to Kansas. As of 1987 this species was confirmed extant at only five sites in Indiana, Kentucky, and West Virginia. *Trifolium stoloniferum* was known historically from eight counties in southern Ohio, the last collection being in 1907. In 1988 this species was rediscovered at eight sites in Clermont, Hamilton, and Warren counties. Population sizes range from 1 to ca. 110 individuals. Historic and modern habitats for running buffalo clover are described. *Trifolium stoloniferum* seems restricted to mesic sites in semishade where there is a pattern of long term disturbance, such as mowing, trampling, or grazing. The decline of running buffalo clover in Ohio seems related to the decimation of herbivores on which the species depended for dispersal and subsequently to maturation of habitats.

INTRODUCTION

Trifolium stoloniferum Muhl. ex A. Eaton (running buffalo clover) (Fabaceae) is a stoloniferous perennial which formerly grew over a broad area of the American Midwest. Brooks (1983) described the geographic range of this species and pointed out its remarkable decline in the twentieth century. Running buffalo clover formerly occurred in the states of West Virginia, Ohio, Kentucky, Indiana, Illinois, Missouri, Kansas, and Arkansas. Yet Brooks was unable to locate any specimens later than a 1940 collection from Webster County, West Virginia. This revelation spurred a search for the clover in West Virginia and its eventual rediscovery in Fayette and Webster counties in that state (Bartgis 1985). In 1987 *Trifolium stoloniferum* was listed by the U.S. Fish and Wildlife Service as an endangered species in the United States. In that same year populations of running buffalo clover were discovered in Indiana and Kentucky (M. Homoya, Indiana Heritage Program, pers. comm. 1987; Campbell et al. 1988).

Five populations of *Trifolium stoloniferum* were known to be extant nationally as of the spring of 1988: Fayette and Webster counties, West

Virginia; Ohio County, Indiana (two populations); and Boone County, Kentucky. The Kentucky population consists of several hundred plants and is the largest so far located.

In 1988 the U.S. Fish and Wildlife Service, Region 3, funded a state-wide status survey for *Trifolium stoloniferum* in Ohio as a part of regionwide efforts to relocate this species. The Division of Natural Areas and Preserves, Ohio Department of Natural Resources, assembled a team of botanists to search for this species in its historic range. The writer coordinated this survey and trained the Division staff. "The Clover Team" included: John Baird, New Richmond, Ohio; Renee Beaudoin, Miami University, Oxford; Susan Smith, Middletown; and Sabina Sulgrove, Dayton. We also were assisted by Division ecologist W. T. Rankin. This paper summarizes our knowledge of historic records of this species in Ohio, presents the results of the 1988 survey, and discusses the factors which led to the decline of this species throughout its range in this century.

Herbarium specimens of *Trifolium stoloniferum* are known from seven counties of central and southwest Ohio, as well as a single county in the east: Belmont, Butler, Clark, Clermont, Clinton, Franklin, Greene, and Hamilton counties. The last known Ohio collection was in 1907 in Belmont County. These historic records for running buffalo clover are mapped as solid dots in Figure 1. The dots indicate only the county distribution since the vague locality data on most nineteenth century specimens precludes exact mapping. At least 28 separate collections of this species are known from Ohio before 1907. Thirteen of these collections are from Hamilton County. A list of these historic collections is available from the author.

The county distribution of Figure 1 differs from that in Brooks (1983) by the omission of Hancock and Warren counties. The Hancock County report is based upon a specimen at ILL collected by E.J. Paddock in 1834. This sheet is cited by Brooks as from "Williamstown". Paddock was a well-known botanist in central Ohio during the 1830's. Most of his specimens were collected in or near Worthington. Franklin County, where he resided (Stuckey 1988). Almut Jones (pers. comm. 1988), curator of the herbarium at ILL, confirmed that the original collector's label reads "Wtn", Paddock's usual abbreviation for Worthington. Paddock's "Wtn" was expanded to "Williamstown" by an unknown hand, apparently when the specimen was accessioned about 1919.

The Warren County record in Brooks is based upon a 1877 collection by J. E. James, also at ILL, labeled "Loveland" with no county indication. The town of Loveland is in Clermont County at the border of Hamilton and

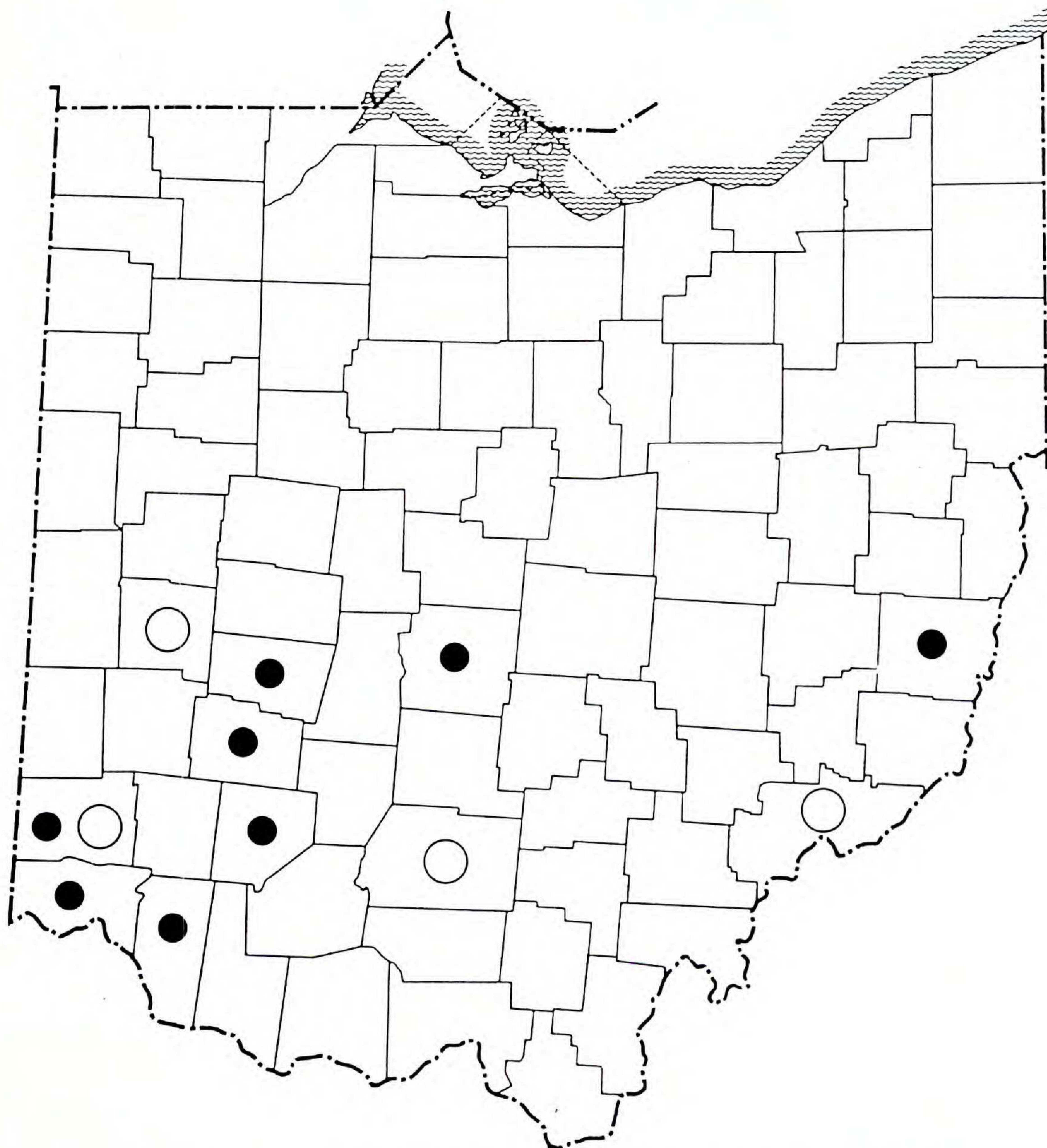


FIG. 1. Historic distribution of *Trifolium stoloniferum* Muhl. ex A. Eaton in Ohio: open circles, 18th century literature reports; solid dots, herbarium specimens, 1830's-1907.

Warren counties. There is no way of knowing exactly from which county James collected this specimen.

Running buffalo clover also is attributed to Sandusky County by Roberts & Cooperrider (1982). This report is based upon a misidentified specimen of *Trifolium repens* L. at OS.

The open circles on the map in Figure 1 represent four eighteenth century references to "clover" or "buffalo clover" as a part of the pre-settlement landscape in Ohio. These reports are discussed in the following section.

HISTORIC HABITATS

There is little historical information on the habitat of *Trifolium stoloniferum* in Ohio at the time of European settlement. Campbell et al. (1988) summarized the historic data on this species in Kentucky, which suggests that running buffalo clover grew in open woods and along trails and water courses. Historic references to running buffalo clover in Ohio are more scarce than in Kentucky because Ohio was not settled until late in the eighteenth century. The four known eighteenth century references are mapped as open circles in Figure 1.

The earliest known reference to clover in Ohio is found in the journal of the British trader Christopher Gist. In 1751 Gist traveled from the Ohio River near the modern Portsmouth to the Indian towns along the Great Miami River near the present Piqua. After leaving the hills of unglaciated Ohio, Gist entered the till plains and reported seeing: "fine, rich level Land, well timbered with large Walnut, Ash, Sugar Trees, Cherry Trees &, it is well watered with a great number of little Streams or Rivulets, and full of beautiful natural meadows, covered with wild Rye, blue Grass and clover, and abounds with Turkeys, Deer, Elks, and most Sorts of Game particularly Buffaloes, thirty or forty of which are frequently seen feeding in one meadow." (quoted in Shriver 1987, p. 54).

These comments by Gist are doubly significant in being the only direct link between *Trifolium stoloniferum* and buffalo, *Bison bison* (Linnaeus), in Ohio. Evidence suggests that this species grew along buffalo traces in Kentucky and, possibly, West Virginia (Bartgis 1985; Campbell et al. 1988). Buffalo were quickly extirpated from Ohio, the last animal reportedly being killed in 1803 (Shriver 1987).

A second early reference to clover in the valley of the Great Miami River is found in a journal kept by a travelling minister, James Smith (1907). In 1795 Smith described the luxuriant vegetation on the terraces of the Great Miami River north of the modern city of Hamilton, noting that "wild rye and clover was here in abundance" (p. 379).

Two writers indirectly link buffalo and *Trifolium stoloniferum* in the valley of the Muskingum River north of Marietta, Ohio. John May, a Boston merchant who arrived at Marietta, the state's first organized settlement, in 1788, twice refers to hunters seeing buffalo along the Muskingum River (Smith 1961, pp. 61, 63). S. P. Hildreth, the foremost historian of the Marietta settlement, described the bottomland near the mouth of the Muskingum River in 1788: "The pea vines, and buffalo clover, with various other plants were nearly knee high, and afforded a rich pasture for their hungry horses" (1848, p. 207).

In 1796 James Finley, a circuit-riding minister from Kentucky, visited

the valley of the Scioto River in the vicinity of the present-day city of Chillicothe. Here he found "a garden of nature" with a variety of tree species and "beneath all, the wild rye . . . mixed with the prairie and buffalo clover" (Strickland 1853, p. 105).

A problem in interpreting the historic records is the possibility that they may refer to the ubiquitous European white clover *Trifolium repens* L. That species was introduced into North America at an extremely early date and quickly became naturalized throughout the continent. John May, the Boston merchant mentioned above, brought "cloverseed" to Marietta in 1788 (Smith 1961, p. 35). This undoubtedly was seed of *T. repens*. Pursh (1816) refers to the occurrence of *T. repens* in disturbed ground as far as 100 miles distant from the nearest habitations. Drake (1815, p. 56) indicates that *T. repens* was a common plant in the Cincinnati region that appeared spontaneously almost immediately following cultivation. Campbell et al. discusses this problem and concludes that almost all pre-1800 reports from Kentucky refer to *T. stoloniferum*. References after that date are more dubious. It is likely that the four eighteenth century references from Ohio refer not to European, but to indigenous clovers. Finley and Hildreth specifically refer to "buffalo clover" and the early date of the Gist and Smith references argue for the indigenous species.

The labels on herbarium specimens of running buffalo clover from Ohio have little habitat description. Although tersely worded, these remarks confirm the presence of the species in open woods and borders and on stream terraces.

The earliest Ohio specimens of *Trifolium stoloniferum* date from the 1830's. An 1834 collection by E. J. Paddock has no habitat data and simply is labelled "Worthington", Franklin County. There are two undated, pre-1840 specimens from Hamilton County. Thomas Lea collected this species in "Riddle's ploughed cornfield" (PH). Riddle's property was along the valley of Mill Creek just north of downtown Cincinnati (Braun 1934). Lea's specimen neatly links the border and stream terrace settings with a recent disturbance. A C.W. Short specimen is labeled "North Bend, Fernbank in woods along Ohio River" (MO). Fernbank is not a habitat description, but the name of a small community which existed for a few years just east of the present North Bend (Ford & Ford 1881). Fernbank was only a few miles east of one of the extant Ohio populations of running buffalo clover. The Short collection confirms the occurrence of the species in an alluvial habitat.

The earliest published reference to *Trifolium stoloniferum* in Ohio is contained in Riddell's catalog (1835). Riddell simply states that this species occurs "fields, o[pen] w[oods], etc., O, Ky." (p. 23). This generalized

description is not particularly useful. However, it does suggest that running buffalo clover was distributed rather generally. No Riddell specimen of *Trifolium stoloniferum* has been located in this study. Riddell might have seen this species in either the Columbus or Cincinnati areas where he lived.

Subsequent Ohio specimens of running buffalo clover lack habitat data with two exceptions. An undated Braun specimen from Hamilton County is labeled "dry fields" (US). This atypical reference is unexplained. A 1907 E. M. Laughlin specimen from Belmont County is labeled "edge of Stur's Woods, low ground". Laughlin's comments confirm the link between this species, edge habitats, and moist situations.

The primeval forests of North America were not as uniform and unbroken as pictured in romance. Running buffalo clover probably survived in a variety of disturbed, successional habitats. Likely situations include animal and human trails, young woods, and openings created by windstorms and fires.

RESULTS OF 1988 SURVEY

Eight Ohio populations of *Trifolium stoloniferum* were discovered in 1988: five in Hamilton, two in Warren, and one in Clermont counties. Voucher specimens are deposited at OS and US. The eight stations are mapped in Figure 2. The five sites in western Hamilton County are clustered in a small area, therefore, the distance between the dots in Figure 2 is considerably exaggerated. Warren County is a new county record for this species. Population sizes range from a single individual to ca 110 plants. The total number is approximately 250–270 plants. This is a significant increase in both the number of sites and individual plants confirmed extant in the national range of running buffalo clover. The largest of Ohio's populations presently is the second largest known site for this species in its total range. *Trifolium stoloniferum* is listed as an Endangered species in the State of Ohio (ODNAP 1988).

The modern habitats of *Trifolium stoloniferum* are in open, moist, disturbed situations. However, it is difficult to pinpoint any single factor linking all the known habitats. Successful searches for this species should not concentrate on a single type of habitat, but must broadly survey a variety of moist openings. Detailed data on habitat, associated species, and location is contained in the database of the Division of Natural Areas and Preserves. Additional information is available to researchers from the author.

The largest of the eight Ohio populations of this species, ca 110 plants, grows at the Miami Fort in the Hamilton County Park District. This is an outstanding archaeological area with earthworks probably built by Indians of the Hopewell culture ca 100 BC to 600 AD (Welsh n.d.). The clover



FIG. 2. Extant populations of *Trifolium stoloniferum* in southwest Ohio, 1988.

population is located within these earthworks. Most of the plants cluster about the bases of large black walnuts (*Juglans nigra* L.) while others grow adjacent to a gravel trail. The opening is moist, grassy, and parklike with filtered light. Typical herbaceous associates of the clover include: *Elymus virginicus* L., *Glechoma hederacea* L., and *Stellaria media* (L.) Cyrillo.

The Miami Fort apparently was heavily forested at the time of European settlement. The earliest description of the site was given by J. Scott Harrison who was born in 1804 at a homestead directly below the Miami Fort. His remarks date from 1838. As a young man Harrison observed the deforestation of the Miami Fort and nearby hilltops. These areas presented "precisely the same appearance as the circumambient forest. You will find on all of them the beautiful variety [of tree species] which gives such universal richness to our forest." (quoted in Ford & Ford 1881, p. 321).

The Miami Fort was acquired by the county park district in 1967. During the 1950's it had been a city park used sporadically by scouting groups and for day camping activities. Its earlier history is not known, but the

isolated, large walnuts suggest that the area was selectively logged at least 50 years ago. It is likely that the fort was grazed as well. Since 1979 the fort has been lightly mowed about once a month from April to September.

Three other populations of *Trifolium stoloniferum* grow in the same Hamilton County park. Two of these are at the edges of footpaths which also are heavily used by deer. The other population is below a black walnut in a picnic area. All three sites share the common disturbance factors of trampling and regular mowing.

The fifth Hamilton County population grows in a cemetery owned and managed by the Ohio Historical Society. This is one of the oldest cemeteries in Ohio, having been established about 1790 (Burress 1987). This is the only extant population of *Trifolium stoloniferum* located in the vicinity of an historic collection of the species. The Short collection of 1834 came from the former settlement of Fernbank only a few miles further east along the Ohio Valley. This cemetery contains the graves of several individuals prominent in the history of Hamilton County. For that reason, the cemetery has been mowed and cleared of brush for an extended period. It was acquired by the Ohio Historical Society in 1935. The cemetery is kept closely mowed, which may benefit the clover by reducing herbaceous competition. As at the Miami Fort, the herbaceous associates are common species, such as *Carex jamesii* Schw. and *Muhlenbergia schreberi* Gmel. The clover grows at this site under the shade of American elms (*Ulmus americana* L.).

Two populations of *Trifolium stoloniferum* grow in mowed and trampled ground near houses. These dooryard sites, as we may call them, are in Clermont and Warren counties. The Warren county population is in a moist path between an 1820's homestead and an old barn. The Clermont County plants grow under a large American elm adjacent to an old stone barn. Herbaceous associates at these sites are weedy, non-indigenous species such as *Glechoma hederacea*, *Polygonum cespitosum* Blume, and *Trifolium repens*.

A single plant of running buffalo clover was located on a sandbar in the bed of an intermittent stream in a ravine in Warren County. Deer commonly are observed in this valley. It is conceivable that this single plant sprang from deer droppings and that the animals had grazed on the clover at a nearby site, so far not discovered.

MODERN HABITATS

Despite the diversity of habitats described above, it is possible to make a few generalizations about the ecological requirements of *Trifolium stoloniferum*.

All but the dooryard site in Warren County are near streams and rivers. The five Hamilton County populations are on slopes or hilltops above the Great Miami or Ohio rivers. The Clermont County site is on the terrace of a small tributary of the Ohio River. The single plant in Warren County is on a sandbar in the bed of an intermittent stream.

None of the extant populations of the clover are in full sun or dense shade. Most, including the largest, are in semi-shade with about 40-50% filtered light. The plants grow under black walnut or American elm or, at one site, tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle).

All sites exhibit some sort of current disturbance. The sources of the disturbance may be mowing or trampling or a combination of both. The four populations in the Hamilton County Park District are along trails and in a picnic grove. Mowing and trampling probably encourages the growth of the clover by reducing competition from herbaceous species.

This disturbance has continued over an extended period of time at most sites. The cemetery has been kept open since the late eighteenth century. The woodland opening at the Miami Fort dates from at least the 1950's and probably is a good deal older. The dooryard populations are adjacent to nineteenth century structures.

All sites but the cemetery are linked to past or present grazing by herbivores. The Hamilton County park supports large herds of deer. The plant in the Warren County ravine is along a deer trail. Although there is no direct evidence of cattle grazing on any of the known sites, this is likely in the case of the dooryard sites and is possible at the Miami Fort. The connection between running buffalo clover and herbivores is discussed in the following section.

It is instructive to compare the Ohio habitats of *Trifolium stoloniferum* with those in other states. The two known West Virginia populations of running buffalo clover occur in alluvial soils of stream terraces. One of the populations is along a jeep trail. Both of the known Indiana populations are located in small ravines of intermittent streams near the Ohio River. The woods are very young, quite open, and lightly grazed by cattle. The clover grows on the slopes, in pathways created by the cattle, in the bed of an old logging road, and on sandbars and cobbles in the streambeds. The Kentucky population is found in a shaded pathway between a 1830's farmhouse and a family cemetery. This path is mowed about twice a year and the area had been pastured until about 50 years ago.

Soil associations apparently play only a minor role in the distribution of running buffalo clover. There is no known correlation between the range of this species and any specialized soil type. The extant Ohio populations

grow in fine-textured, loamy soil of alluvial or lacustrine origin (Lerch 1971; Lerch et al. 1980; Smith 1964).

In general terms, *Trifolium stoloniferum* grows in semishade in a variety of moist openings and edge habitats which are maintained by long-term disturbance of a moderate nature. The species is not found in mature habitats nor in areas of severe disturbance. There may be a direct link between the occurrence of this species and grazing by herbivores.

PHENOLOGY AND REPRODUCTION

Trifolium stoloniferum blooms in Ohio from mid May through early June. In 1988 the peak of bloom had already past by 24 May. This brevity of bloom is an important difference between running buffalo clover and the common *Trifolium repens* which often blooms till frost. Nothing is known about possible pollinators of the flower.

Mature seeds were obtained from two populations of *Trifolium stoloniferum* on 6 July 1988. By that date most leaves were withered and the plants difficult to locate among the surrounding vegetation. However, it is uncertain what role weather plays in the phenology of this species. The summer of 1988 was excessively hot and dry in southwest Ohio; the observed phenology may have been atypical. Persistence of the leaves and stolons may depend on moisture. The plants at the Miami Fort were almost totally withered by mid September 1988. However, at the same time the stolons were green and flourishing at the two dooryard sites where more water was available.

Trifolium stoloniferum reproduces both by seeds and vegetatively by stolons. It is unknown whether seed production results from selfing or outbreeding. The seeds of running buffalo clover remain in the legume until the outer walls of the pod are broken down mechanically by exterior forces. The thick seed coats require scarification for germination (Campbell et al. 1988; J. Foster, USDA, pers. comm. 1989). Herbivory is the most likely means of dispersal of running buffalo clover. The plants undoubtedly are browsed by deer and other animals. They are known to be palatable to rabbits which in one documented case selectively ate *T. stoloniferum* leaving nearby plants of *T. repens* untouched (Davis 1987).

If indeed the distribution and reproduction of running buffalo clover are linked to herbivory, the most likely animal in Ohio is deer. Buffalo always were rare in Ohio (Shriver 1987). The two references to both buffalo and the clover in Ohio are quoted above. Most of the known populations occur in areas with large herds of deer. The plants frequently grow in clusters of four or five individuals, suggesting deposition of the seeds in the feces of deer.

Seeds and cuttings from selected Ohio populations were gathered 6 July 1988 by Joyce C. Foster, USDA, Beckley, West Virginia. Viable seeds germinated after refrigeration for two months followed by scarification with sandpaper. The cuttings also rooted successfully.

DECLINE

The number of historic collections of this species indicates that *Trifolium stoloniferum* formerly was relatively frequent in central and southwest Ohio, particularly in the vicinity of Cincinnati. The twentieth century saw a remarkable and sudden change. What factors lead to this precipitate decline?

Habitat destruction is the obvious answer to this question. However, the species itself grows in disturbed situations and probably requires disturbance to maintain itself. Campbell et al. (1988) suggested the best answer to this paradox—the lack of historical continuity of disturbance.

Running buffalo clover apparently has a poor dispersal mechanism. Deforestation created many new habitats, but there was no efficient means by which the species could move into new sites from remnant populations. The destruction of the original forest coincided with the decimation of the herbivores upon which the clover probably depended for dispersal. The new openings quickly were usurped by alien species such as *Trifolium repens*. Deer virtually disappeared from Ohio in the nineteenth century and only have flourished under management in the past 50 years.

In the twentieth century the lack of disturbance probably played a contradictory role in the decline of running buffalo clover. Woodlands were allowed to mature, increasing the shade under which the clover cannot grow. Remnant populations became even more isolated, persisting in openings maintained by appropriate disturbance. At least some of the extant populations of running buffalo clover may have persisted in place for several decades.

The high palatability of this species also may have contributed to its decline. The cattle of European settlers were greater in number than the indigenous herbivores. The grazing pressure was much more intense than in pre-settlement times.

Other biological and environmental factors as yet unknown may have contributed to the decline of *Trifolium stoloniferum*. Among these possibilities are disease and the disappearance of a pollinator and resultant reduction in outbreeding. Suppression of woodland fires might have led to the closure of suitable habitats. *Trifolium stoloniferum* is the only taxon in this genus which lacks rhizobial bacteria (Campbell et al. 1988). Has the infecting bacterium been lost?

Some or all these factors probably acted in concert and led to the virtual extirpation of running buffalo clover from Ohio and most of its geographic range.

MANAGEMENT AND PRESERVATION

Successful management for *Trifolium stoloniferum* must tread a thin line between too little and too much disturbance. Most populations have withstood mowing or trampling over time with little effect. Mowing seem especially important in controlling the alien weedy species Japanese honeysuckle (*Lonicera japonica* Thunb.) and garlic-mustard (*Alliaria petiolata* (Bieb.) Cavara and Grande. (This latter species often is known by the later name *A. officinalis* Andrz. ex Bieb.; see Clapham et al. 1962). At the Miami Fort the unmown woodlands and shady openings are carpeted with garlic-mustard. This species is only a minor element of the groundcover in the area maintained by regular mowing. There seems no reason to drastically alter existing disturbance regimes. Mowing might be suspended in early May to allow flowering and resumed in mid July after seed set.

The prospects are bright for preserving *Trifolium stoloniferum* in Ohio. Four populations, including Ohio's largest, are owned by the Hamilton County Park District. The park district is most willing to cooperate in protecting these populations and plans to monitor the species over time. The presence of running buffalo clover will be taken into account in management plans being prepared by the Ohio Historical Society for the cemetery site (M. Pratt, pers. comm. 1988). The owners of the dooryard sites have registered their populations with ODNAP as Ohio Natural Landmarks.

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Champaign, checked specimens of this species in the herbarium at that institution. Marilyn Ortt, ODNR, brought the Hildreth reference to buffalo clover to my attention. The U.S. Fish and Wildlife Service provided financial support and encouragement. The Division of Natural Areas and Preserves thanks James Engel and William Harrison of the U.S. Fish and Wildlife Service for their support and assistance.

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